# Molecular gas in cluster galaxies :

# the case of CL1411.1-1148 at $z$ = 0.52

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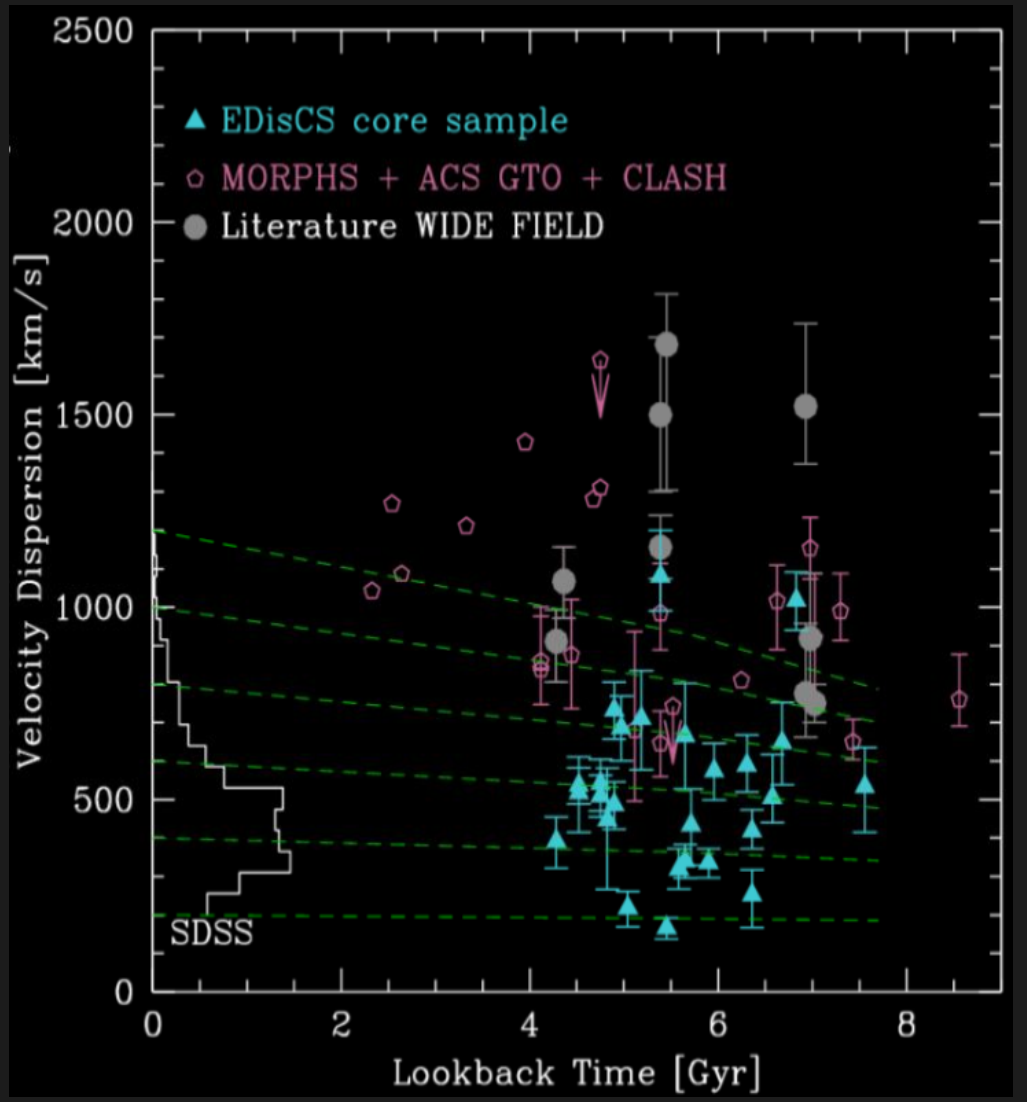
EPFL

# EDisCS: ESO Distant Cluster Survey

- 18 clusters at $0.4 \lesssim z \lesssim 0.8$
- $200 \text{ km/s} \lesssim \sigma \lesssim 1100 \text{ km/s}$

  $(10^{13} M_{\odot} \lesssim M_{clus} \lesssim 1.5 \times 10^{15} M_{\odot})$

Likely progenitors of local galaxy clusters

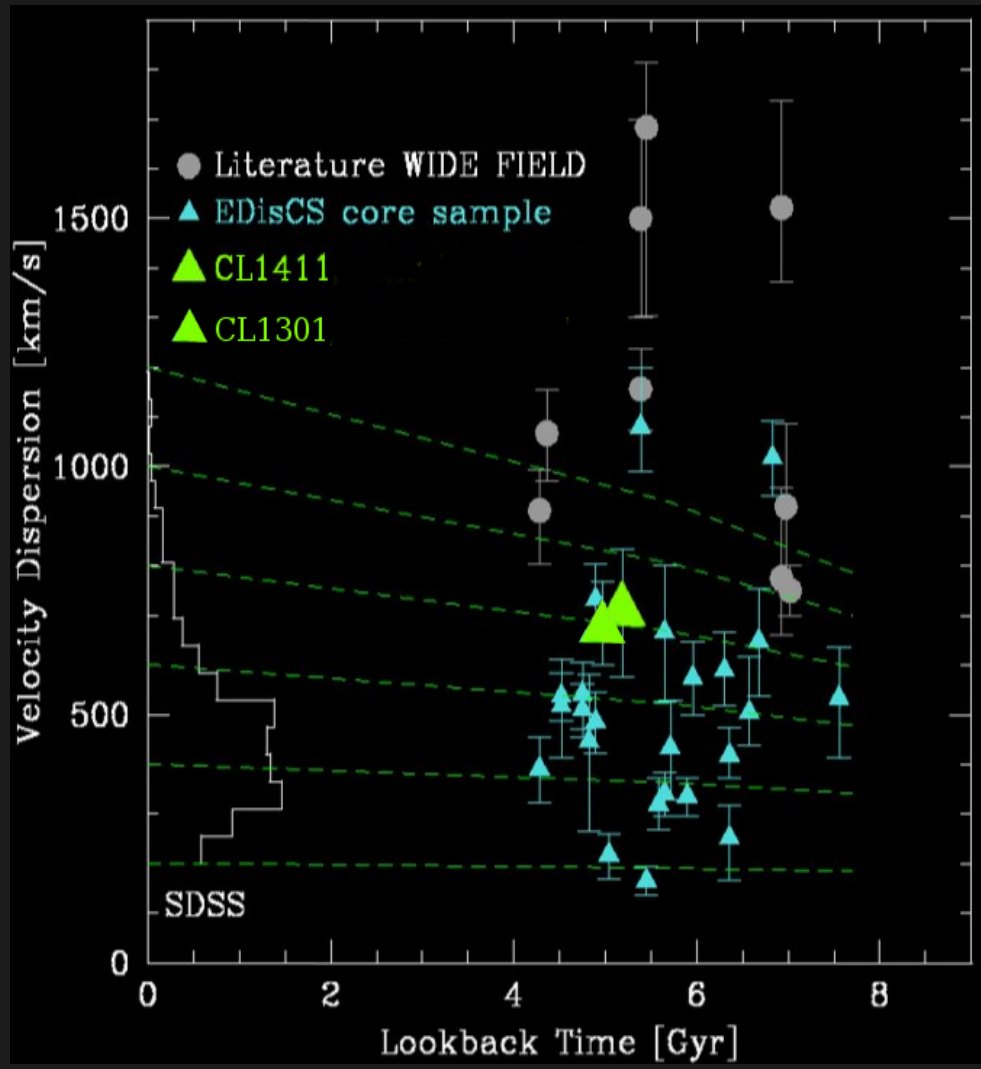



White+ 2005

# SEEDisCS: Spatially Extended EDisCS

PI : P. Jablonka

- 2 EDisCS clusters: CL1411.1-1148 & CL1301.7-1139 at z = 0.52 and 0.48
- CFHT/MEGACAM & WIRCAM: *u, g, r, i, z* and *Ks* – 1x1 deg²



# SEEDisCS: Spatially Extended EDisCS

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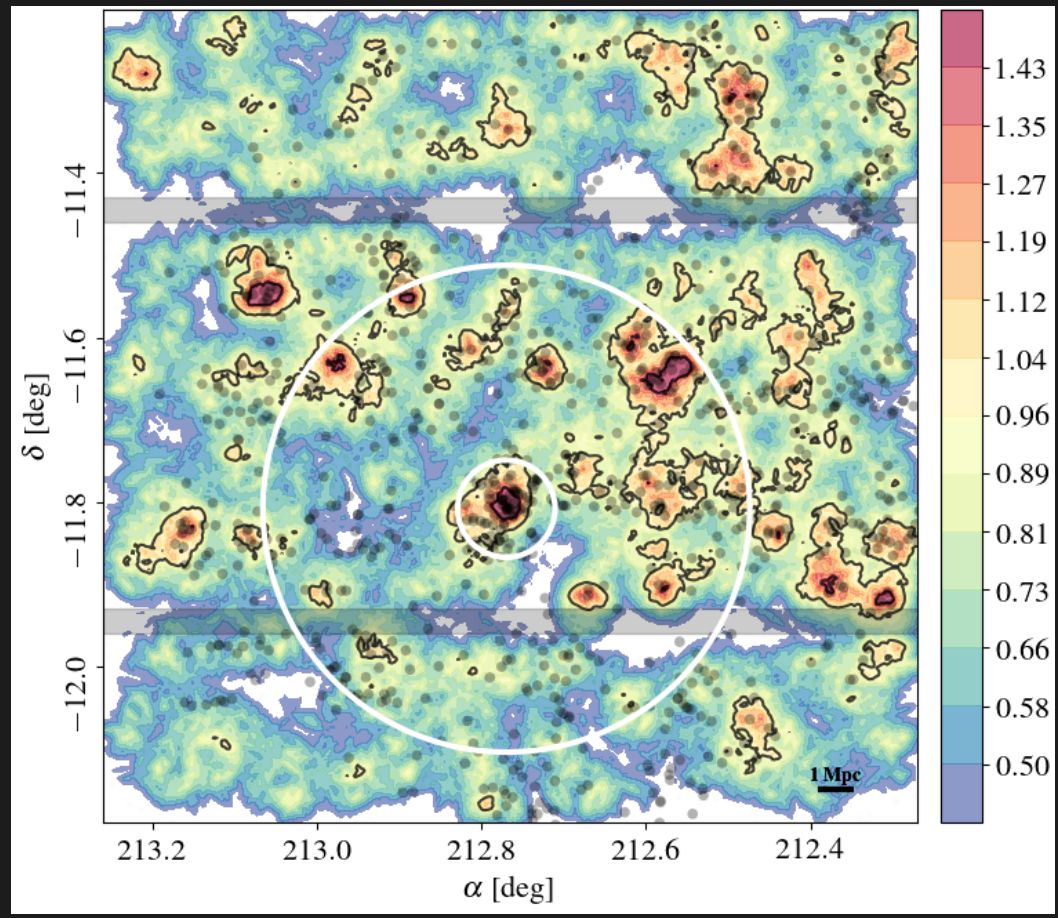
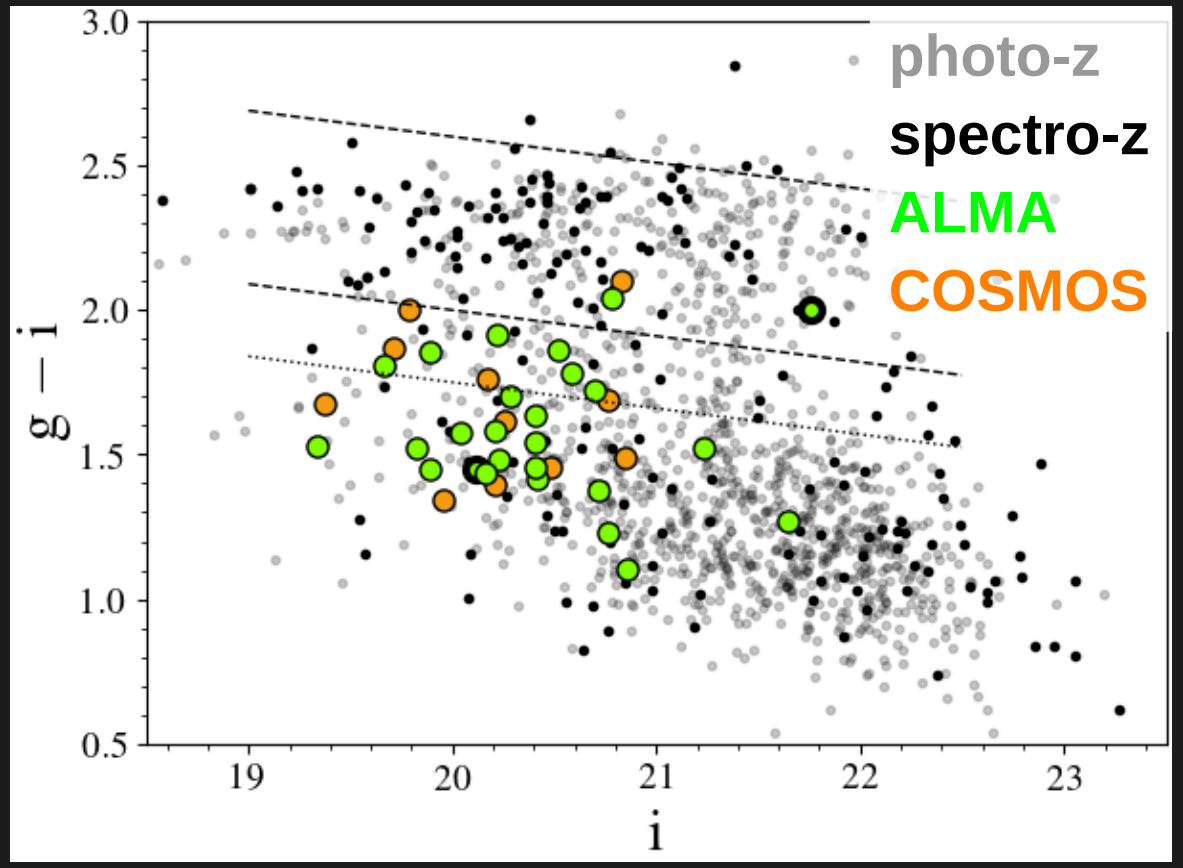
- 2 EDisCS clusters: CL1411.1-1148 & CL1301.7-1139 at z = 0.52 and 0.48
- CFHT/MEGACAM & WIRCAM: *u, g, r, i, z* and *Ks* – 1x1 deg²
- Large spatial coverage (up to $8R_{200}$)
- Photometric redshifts based density maps
- ~ 300 galaxies with $z_{spec}$ ~ 0.5
- ALMA observations of ~ 50 galaxies to get their gas content



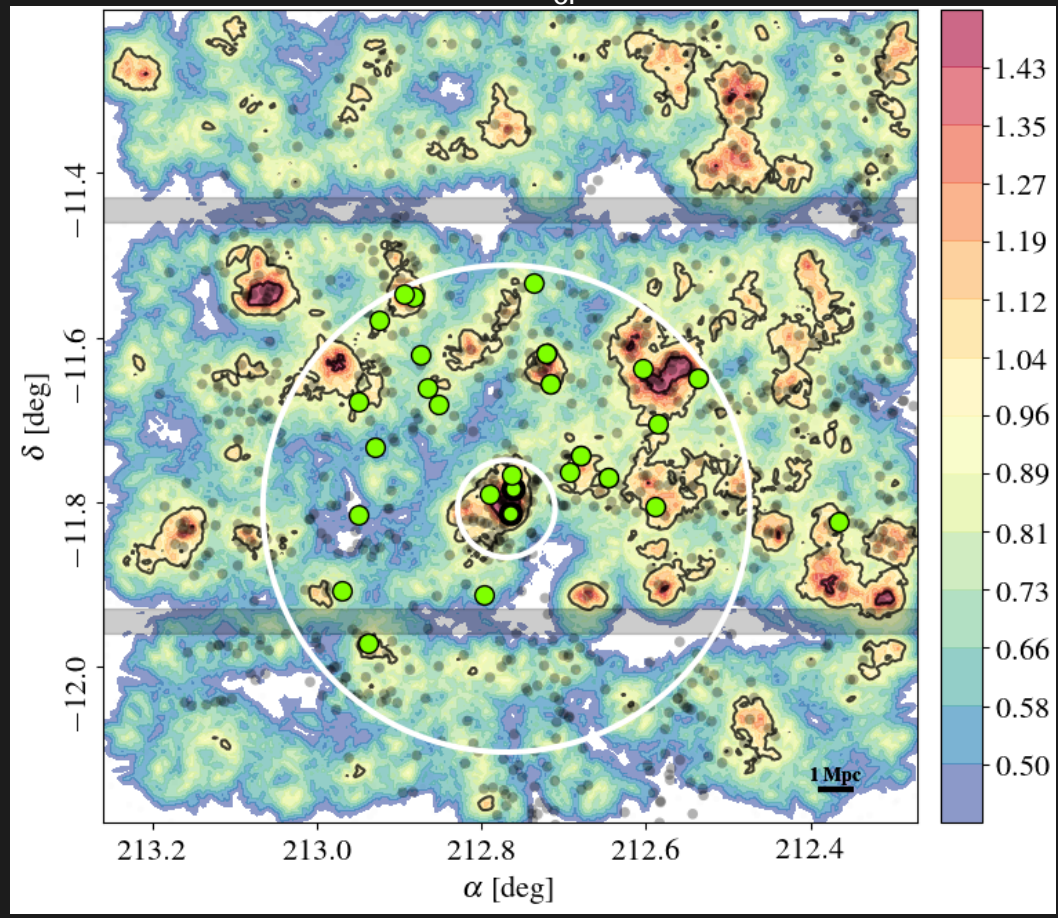

Photometric density map

# Cold gas : ALMA

27 star-forming galaxies with $z_{spec}$
targeted in CO(3-2) @ 226GHz with ALMA
~11h in Cycle 3 and 5
27 detections




CL1411.1-1148
$z$ = 0.5195 $\sigma_{cl}$ = 710 km/s




Photometric density map

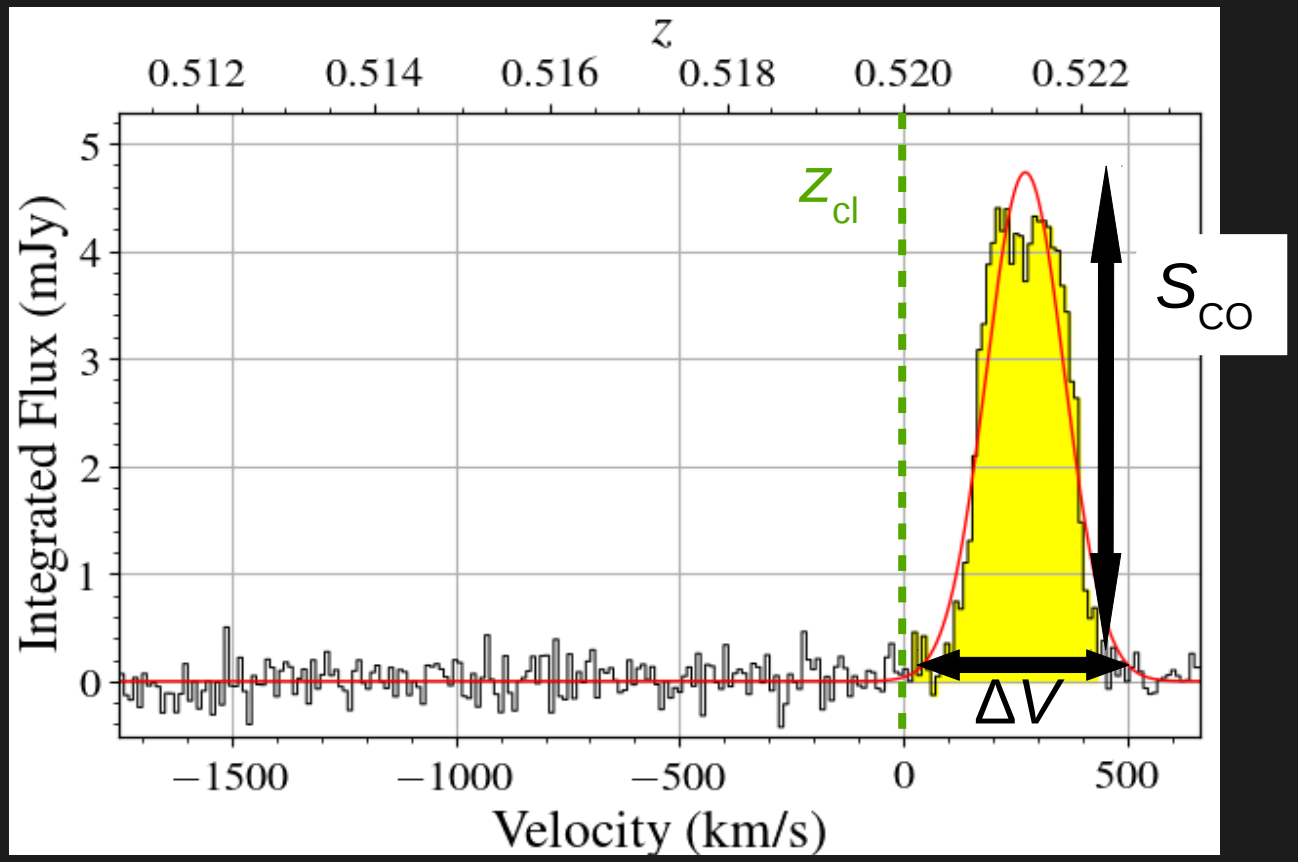
# Cold gas : ALMA

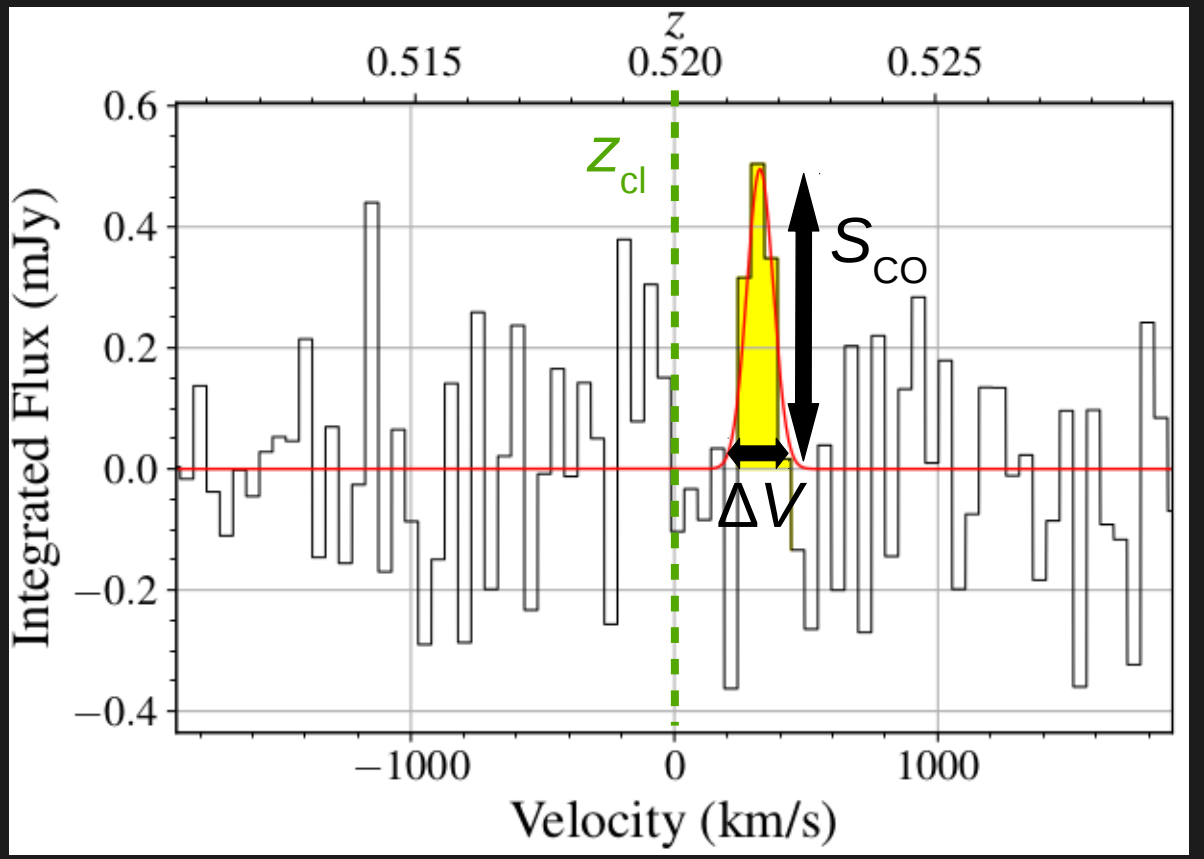
$$M_{H_2} = \alpha_{CO} \frac{L'_{CO(J \to J-1)}}{r_{J1}}$$

$L'_{CO(J \to J-1)} \propto S_{co} \times \Delta V$ Solomon & Vanden Bout 2005

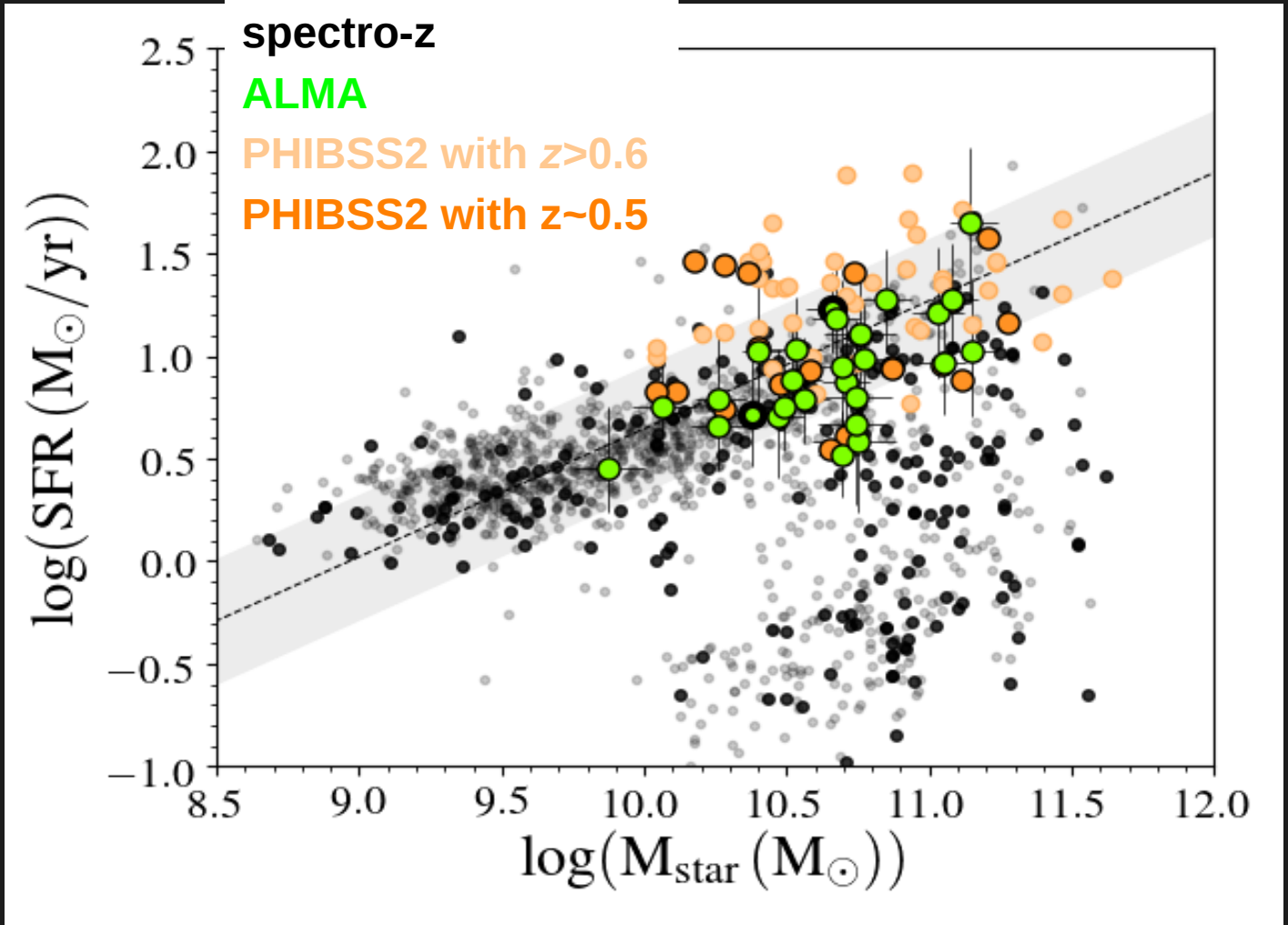
$\alpha_{CO} = \alpha_G = 4.36\ M_\odot (K\ km/s\ pc^2)^{-1}$ Carleton+ 2017

$r_{31} = 0.5$ → from CO(3→2) to CO(1→0) Genzel+ 2015



# Main sequence




SFR and $M_{star}$ derived using MAGPHYS

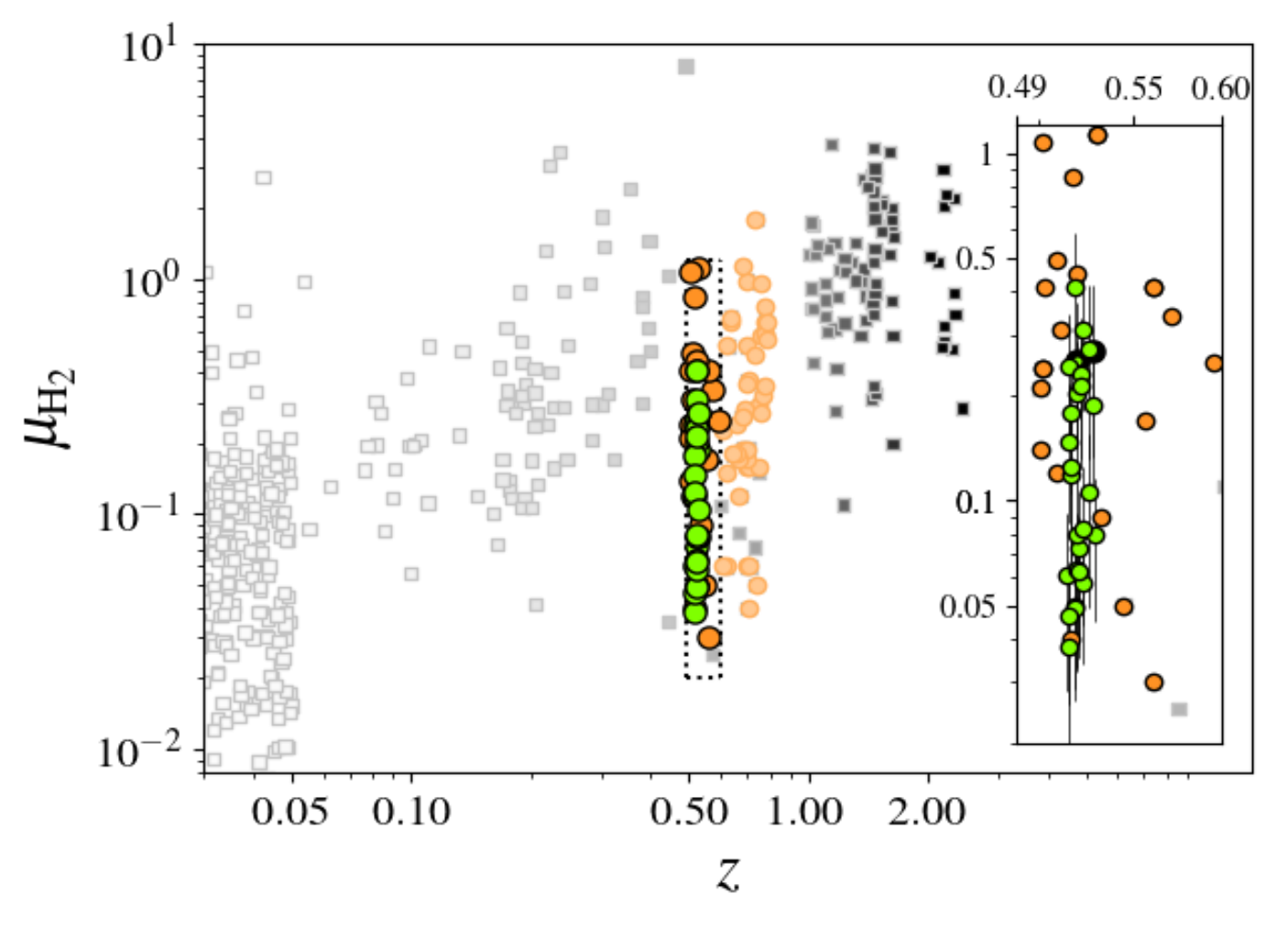
Main sequence is evenly sampled

78% of our ALMA targets within the MS dispersion

MS : Speagle+ 2014

PHIBSS2 : Freundlich+ 2019

# Gas-to-stellar mass ratio

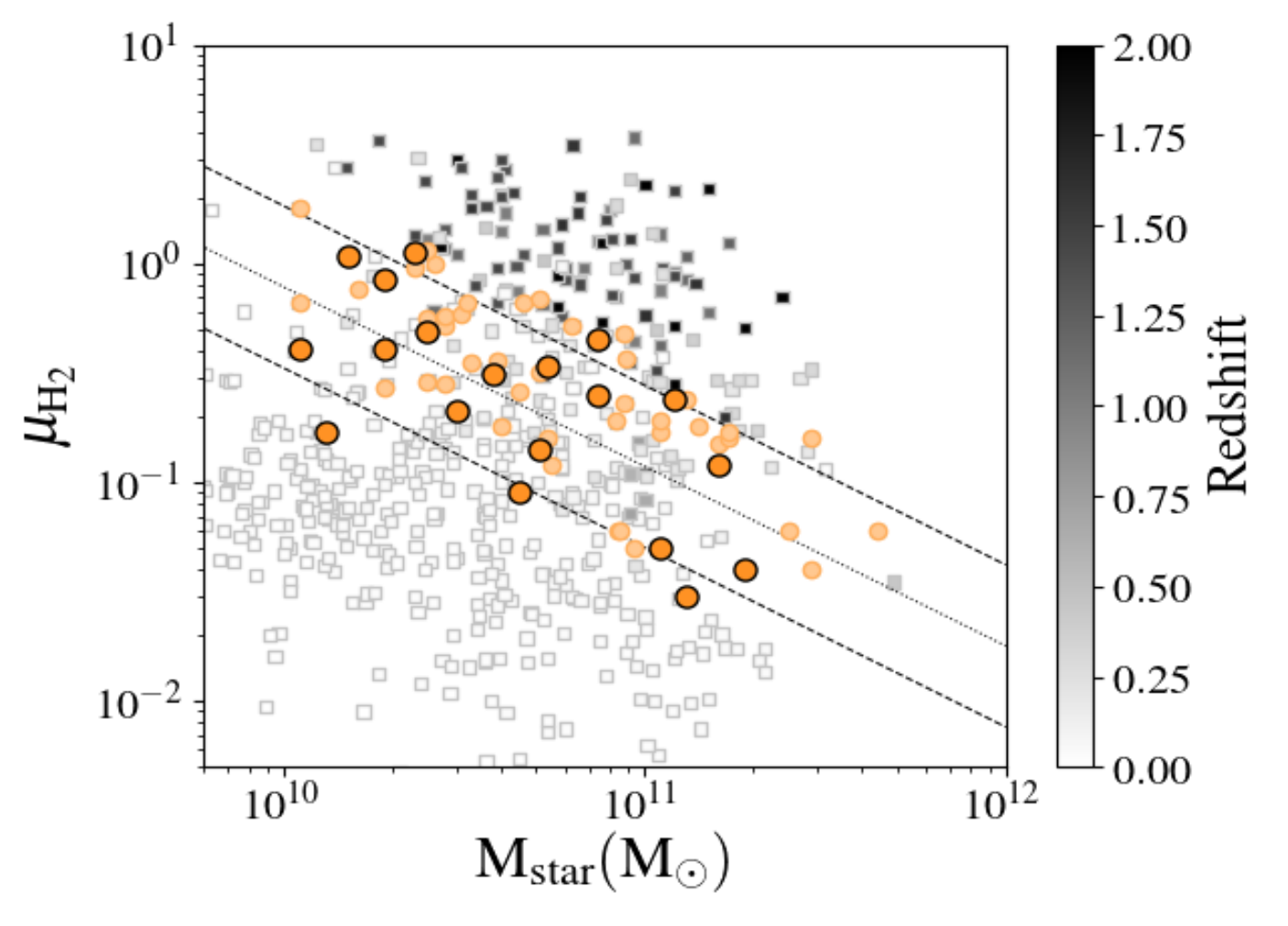



$$\mu_{H_2} = M_{H_2}/M_{star}$$

Galaxies probing a very wide range of gas-to-stellar mass ratios and very similar to PHIBSS2 : from 0.4 down to <0.04

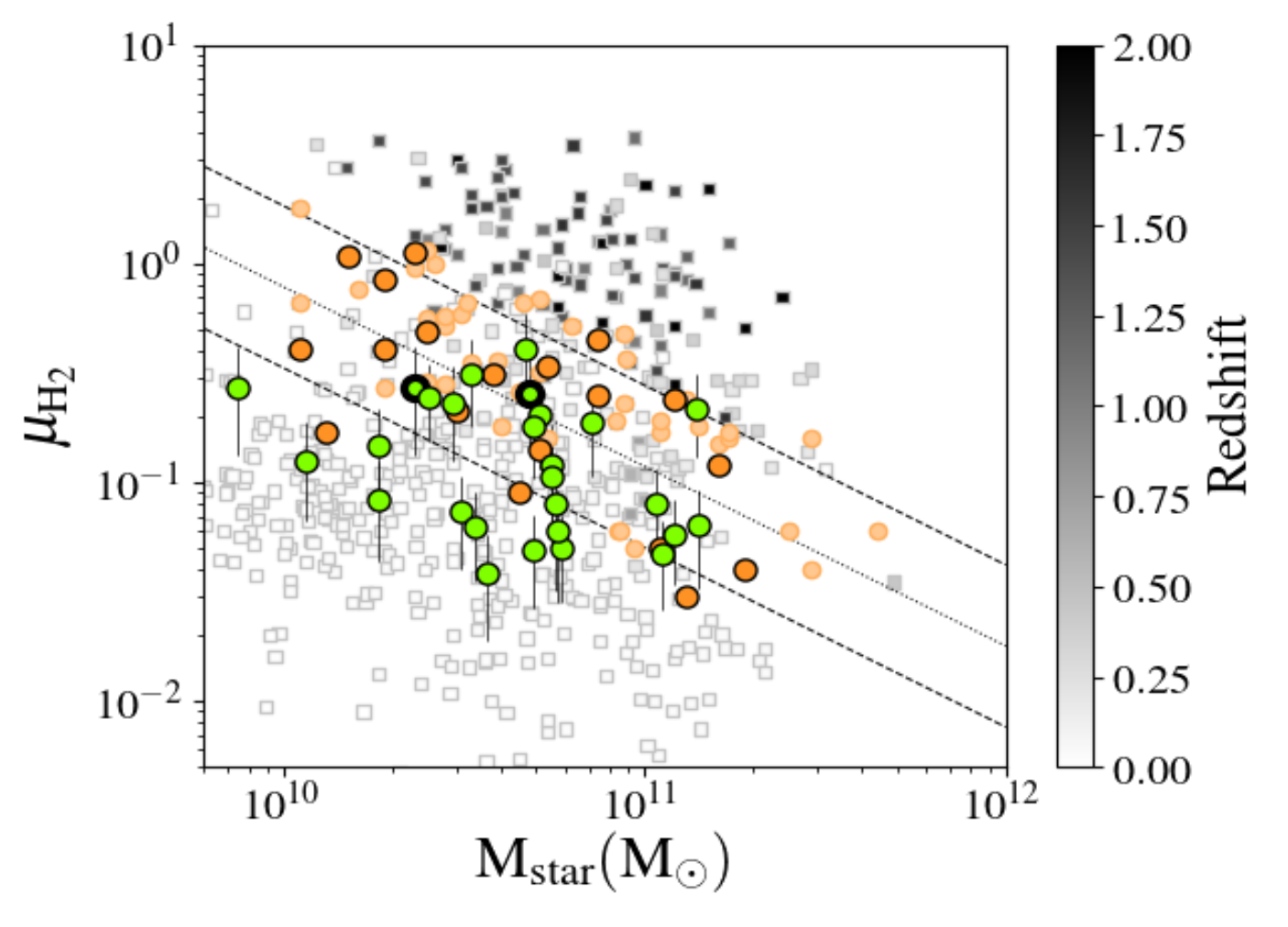
Redshift is coded in grey : the darker, the larger

# Gas-to-stellar mass ratios vs $M_{star}$

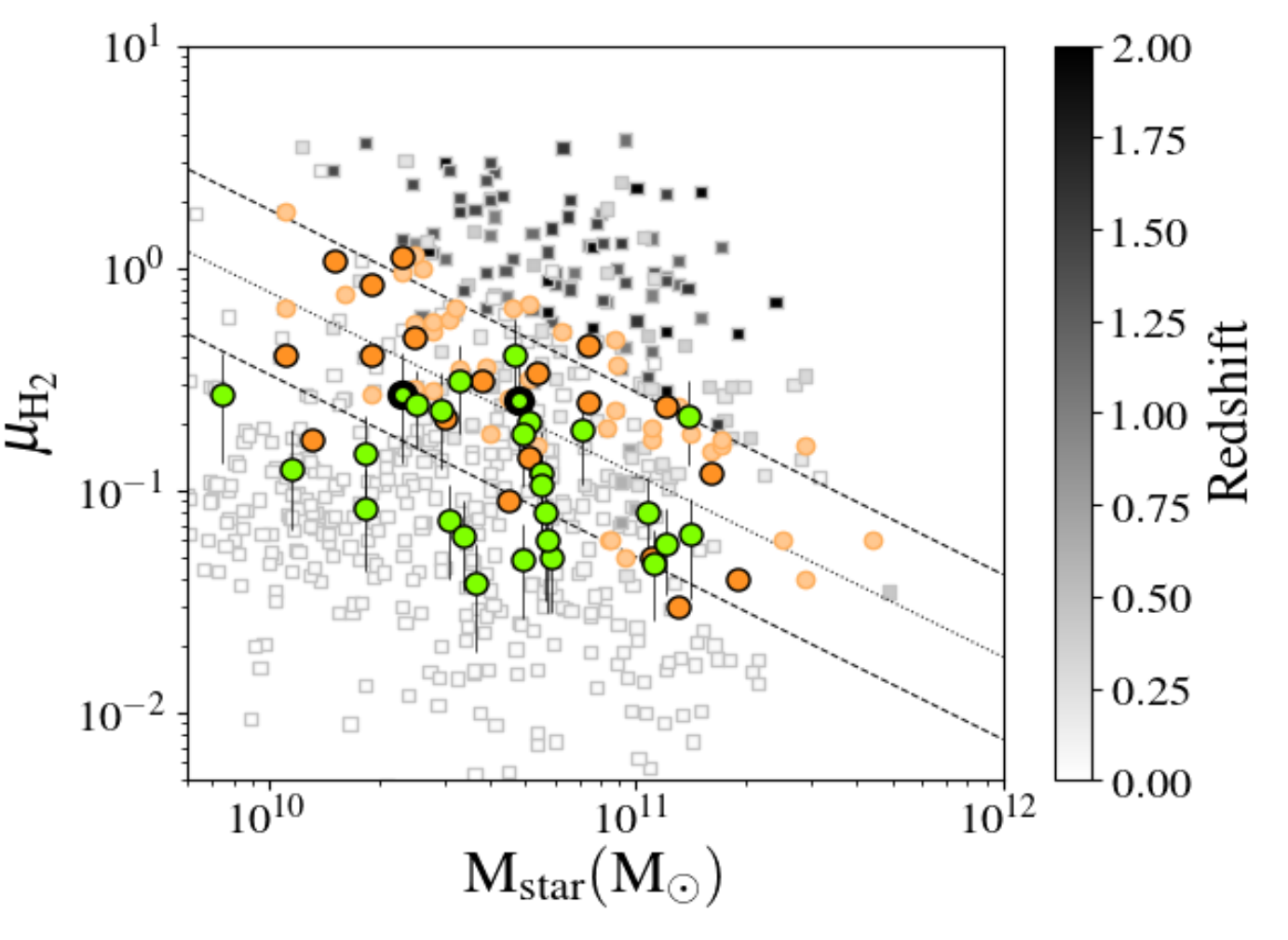



Relation derived from the PHIBSS2 galaxies at $z$ ~ 0.5

# Gas-to-stellar mass ratios vs $M_{star}$



# Gas-to-stellar mass ratios vs $M_{star}$

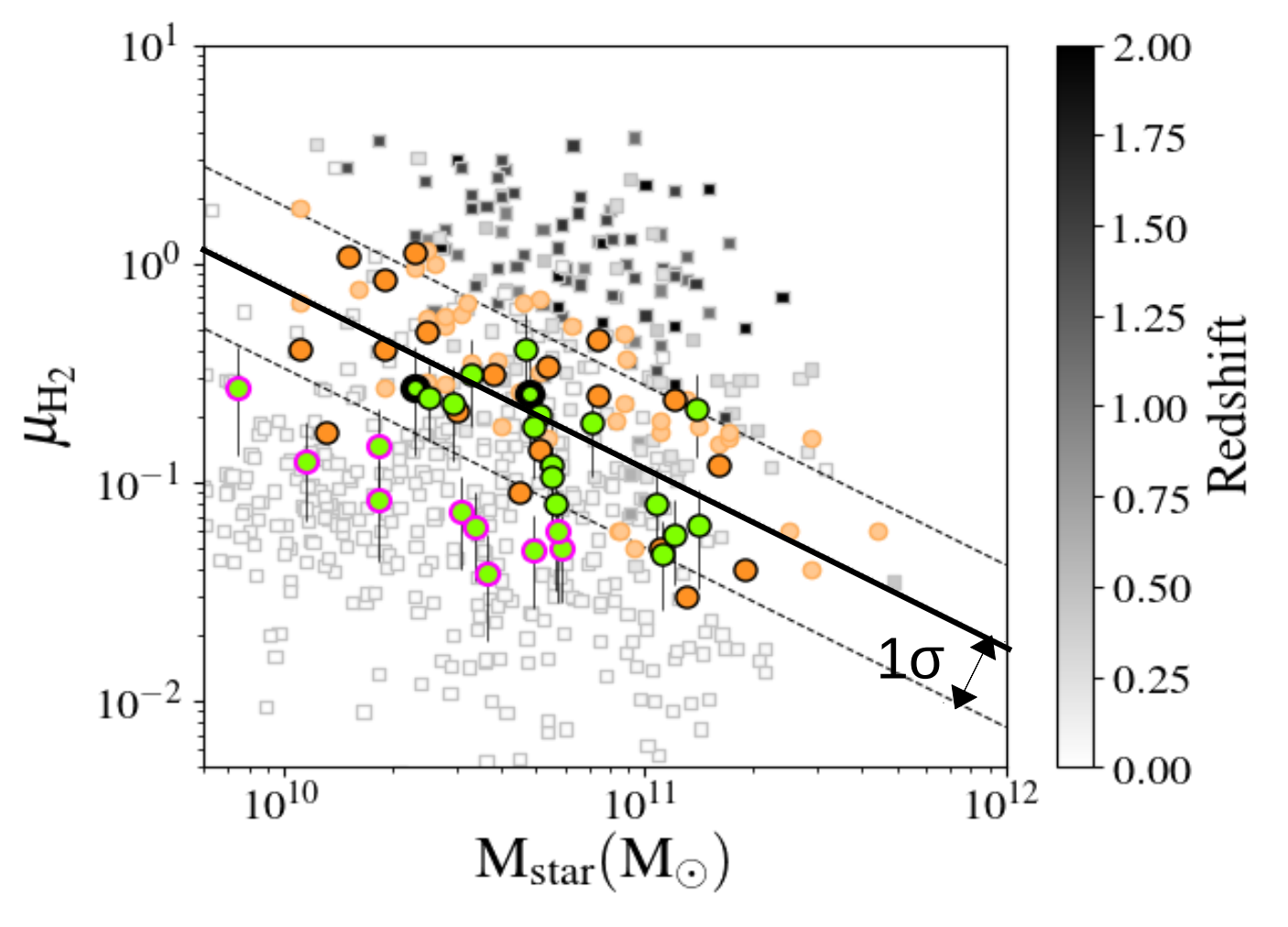



63% of our targets are similar to PHIBSS2 field galaxies

37% are populating a low $\mu_{H2}$ area

=> significantly deviant from the expected tail of a Gaussian distribution

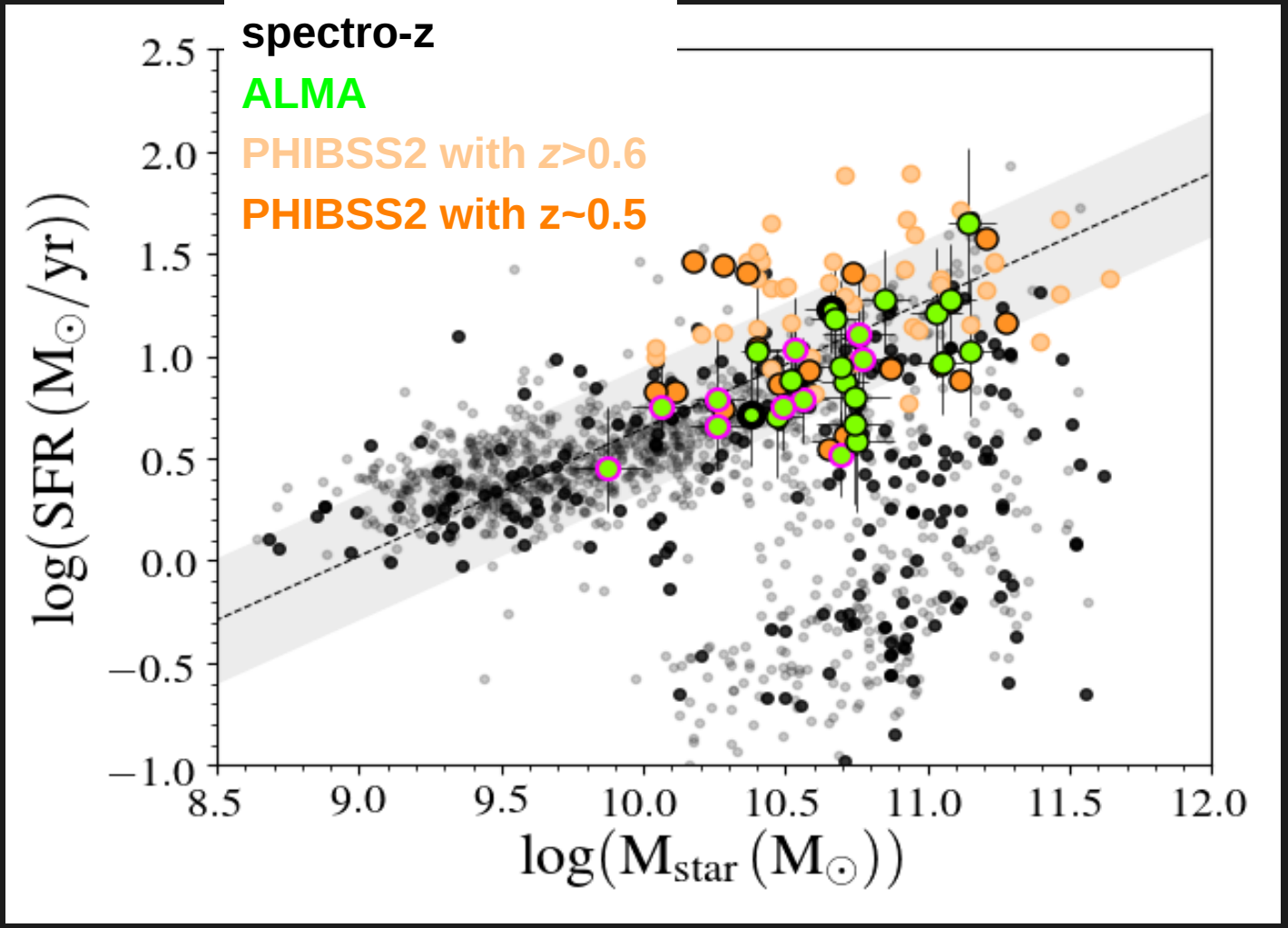
# Low $\mu_{H2}$ galaxies




This new population is defined as:

- having a $\mu_{H2}$ below the dispersion of the previous $\mu_{H2}$ vs $M_{star}$ relation

# Low $\mu_{H2}$ galaxies in the MS

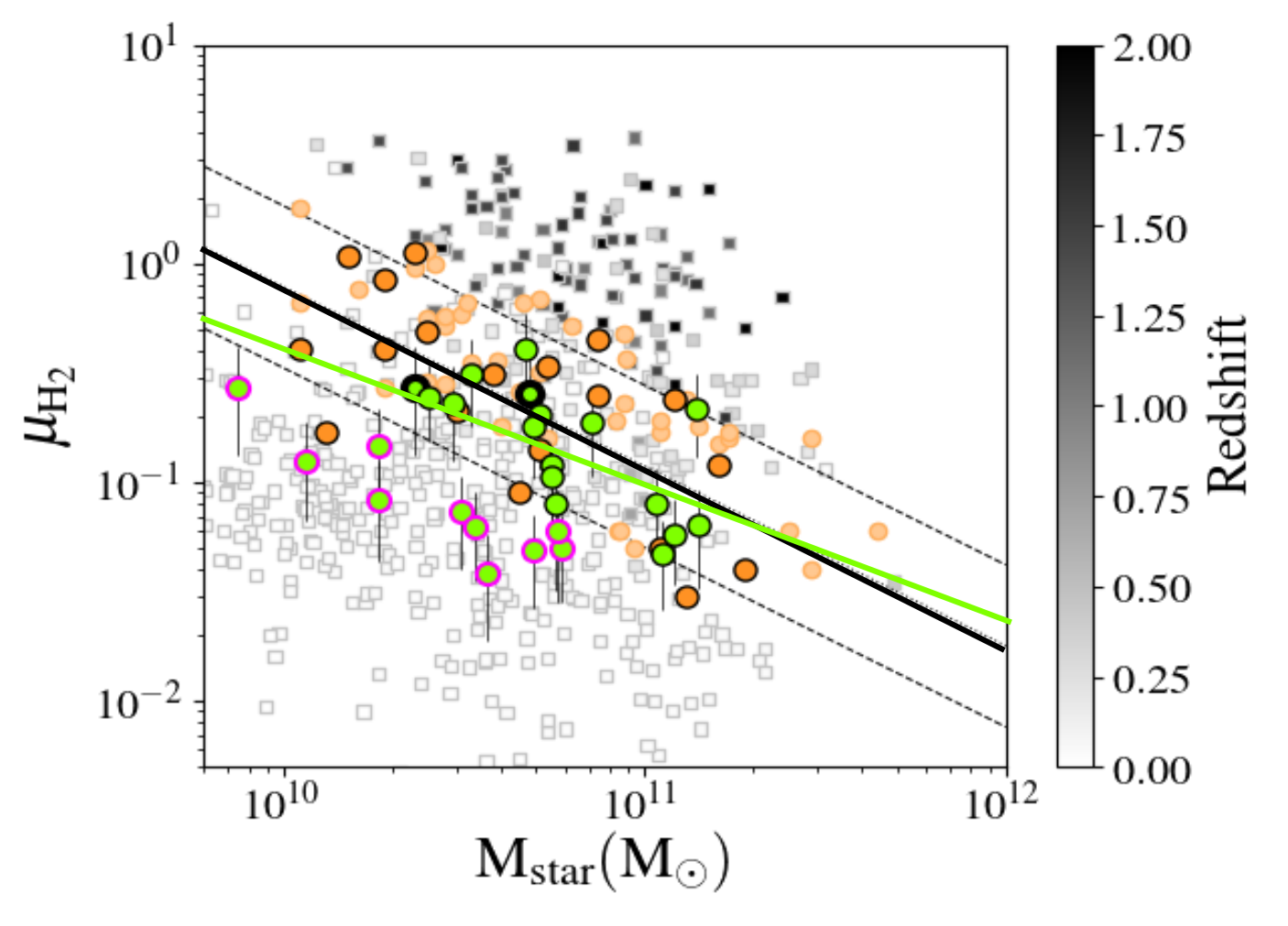



Within or very close to the ± 0.3dex dispersion of the MS

=> is the $H_2$ reservoir impacted before SF activity is ?

1 galaxy transitioning to a quenched state

# Gas-to-stellar mass ratios vs $M_{star}$

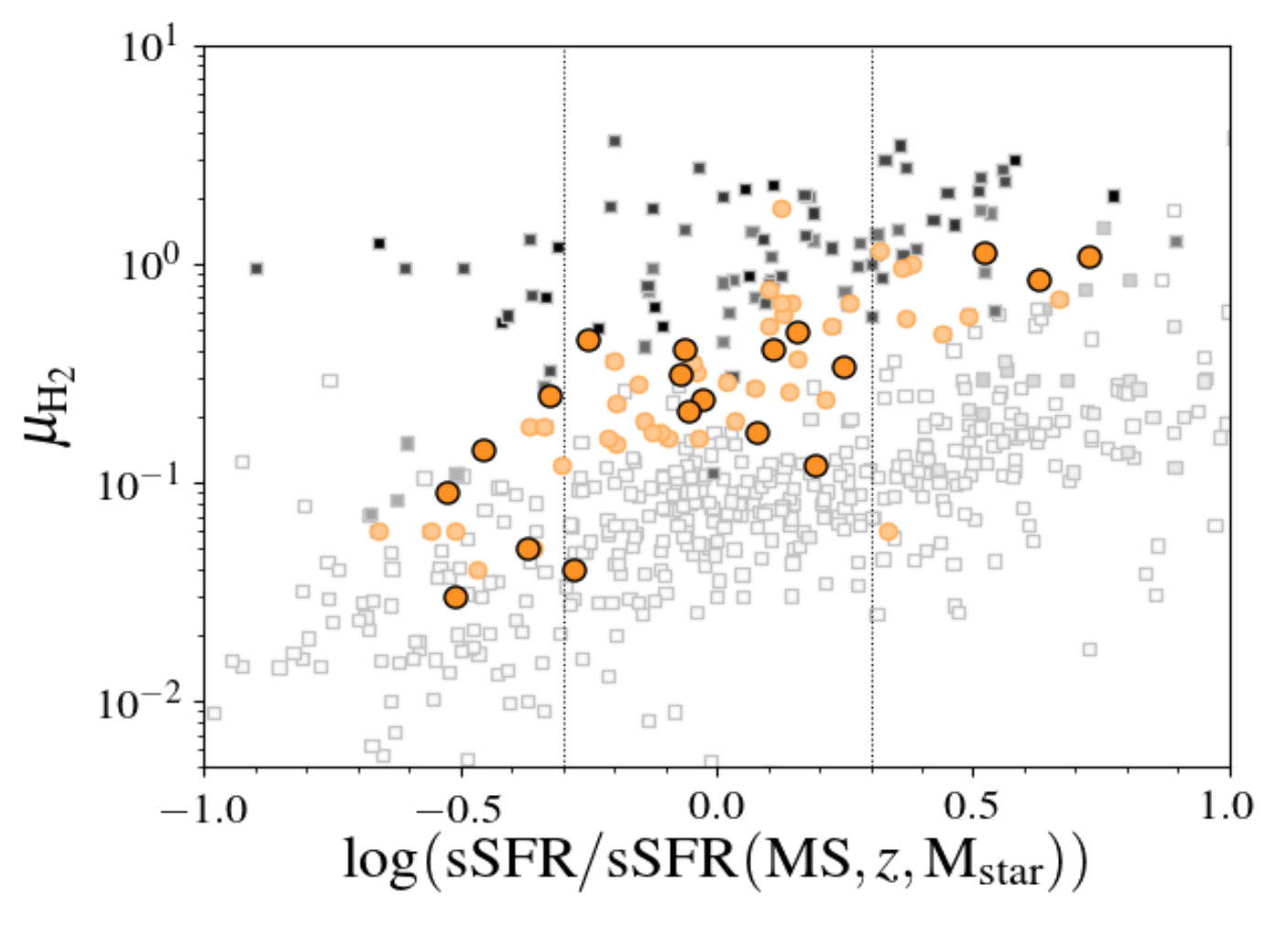



Relation between $\mu_{H2}$ and $M_{star}$ not as steep as shown by PHIBSS2 @ $z$ ~ 0.5

Old relation R = -0.74

New relation R = -0.51

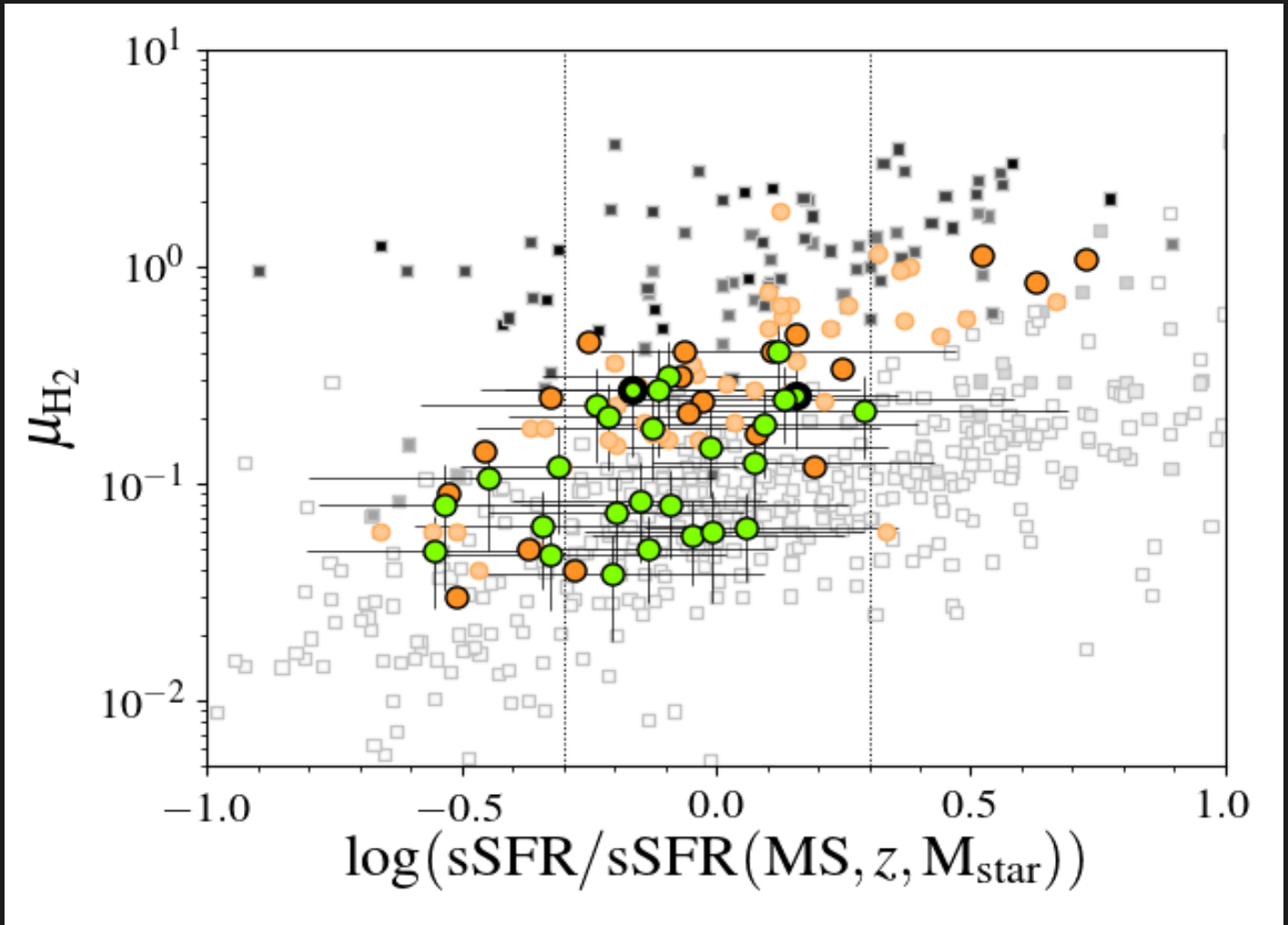
# $\mu_{H2}$ vs sSFR




Existence of a trend for galaxies at $z$ ~ 0.5

Redshift is coded in grey : the darker, the larger

# $\mu_{H2}$ vs sSFR



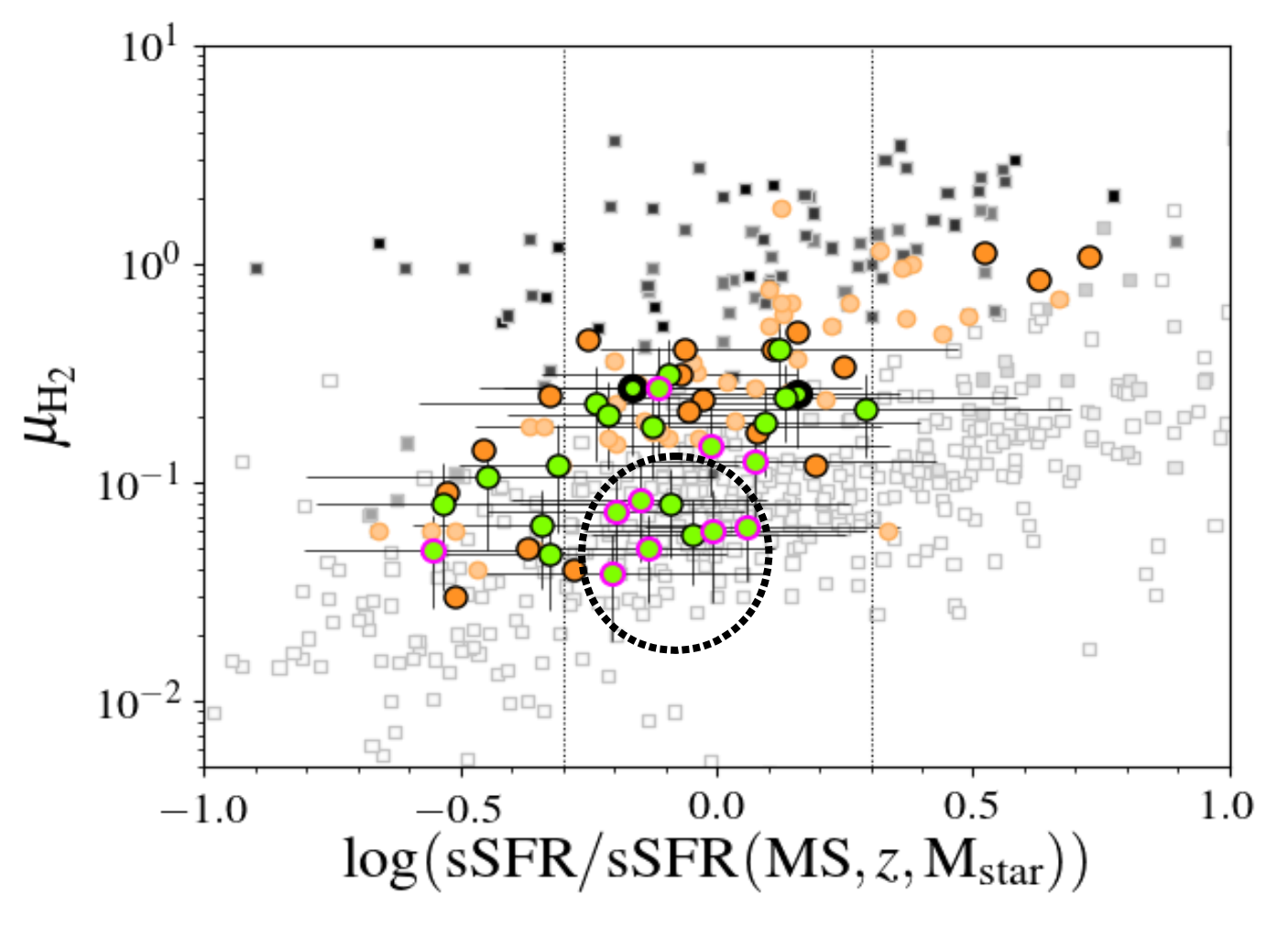

Existence of a trend for galaxies at $z$ ~ 0.5

Most of our galaxies follow this trend

~ 3 x larger scatter in $\mu_{H2}$ at fixed SFR and $M_{star}$

Redshift is coded in grey : the darker, the larger

# $\mu_{H2}$ vs sSFR




Existence of a trend for galaxies at $z$ ~ 0.5

Most of our galaxies follow this trend

~ 3 x larger scatter in $\mu_{H2}$ at fixed SFR and $M_{star}$

A new area is populated
=> tail of the distribution

Redshift is coded in grey : the darker, the larger

# In a nutshell

- 1st large sample within the same cluster environment − 27 detections using ALMA
- 63% of the targets have similar gas content to other field galaxies (PHIBSS2)
- 37% have low $\mu_{H2}$ despite being on the main sequence
- Indications of gas reservoirs being impacted before SF activity is, for the low $\mu_{H2}$ galaxies

=> New population unveiled

=> New selection criterion

=> Different environments